Fall 2004

Swoosh and Boom

QUARTERLY

Indian Head Division
Naval Surface Warfare Center

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Welcome to our Fall 2004 issue of *Swoosh and Boom* Quarterly. What you'll learn from reading our publication is that our mission is concentrated in a core area-energetic systems. Energetics are explosives, propellants and pyrotechnics, and are commonly known throughout the Department of Defense as ordnance.

Our cadre of scientists, engineers and administrative professionals work on those things that go "swoosh and boom." Worth imagining is the remarkable scientific and technical innovation that goes into making the swoosh more exact and the boom more precise. I believe you will be impressed by the various military technical problems we take on and the ordnance solutions we provide.

Our knowledge and mission responsibilities have grown and improved over time. We started out in 1890 as a proving ground for Navy guns. We later evolved to an ordnance production station, and then to what we are today - a vastly-experienced and highly motivated workforce performing a Navy laboratory function with a focus on energetic systems.

We have an important job to do. We are working everyday to become more efficient and effective stewards of taxpayers' dollars. Our aim is to deliver the highest quality energetic systems to our men and women in military uniform. Our overarching drive is to give our military the tools they need to fight and win the global war against terror so they can return safely to their families.

Thank you for your interest in this issues' presentation of the latest scientific achievements of our 1,500-member family, the Indian Head Division, Naval Surface Warfare Center.

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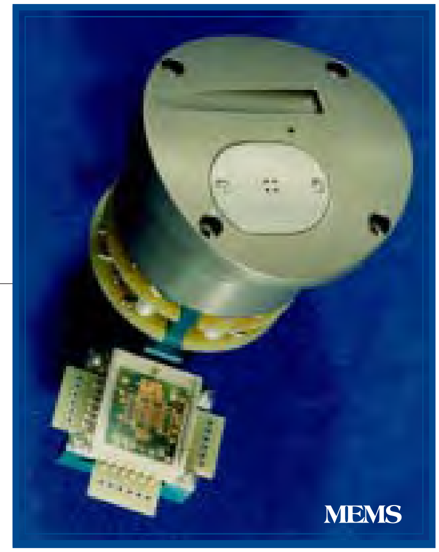
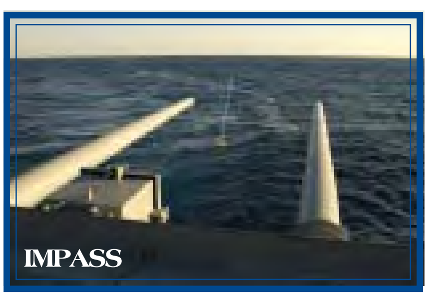


We ensure operational readiness of the United States and allied forces by providing technical capabilities necessary to rapidly move any “energetics” product from concept through production, to operational deployment. Our capabilities include: research, development, testing, and engineering; acquisition; manufacturing technology; manufacturing; industrial base, fleet, and operational support for warheads; explosives; propellants; pyrotechnics; energetic chemicals; rocket, missile, and gun propulsion systems; missile simulators, trainers, and test and diagnostic equipment; tri-service cartridge-actuated devices, propellant-actuated devices, and aircrew escape propulsion systems; and other ordnance products.

Our capabilities provide technical expertise for special weapons, explosive safety, and ordnance environmental support. These technical capabilities and expertise support all Naval warfare areas as well as the Army, Air Force, and private sector.



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With the F-15 sled vehicle traveling at 638 knot-equivalent-air-speed (KEAS), the rocket motor of the CKU-5C/A ignites, propelling the ejection seat out of the cockpit (see full story on page 8).

Ordnance Penalty Simulator (OPS) Concept

by Miguel A. DeLeon
Weapons Simulation Department

Thorough and accurate training can mean the difference between life and death for Explosive Ordnance Disposal (EOD) personnel. IHDIV Simulation and Systems Engineering Division has developed a concept called the Ordnance Penalty Simulator (OPS) to make EOD training more effective and realistic.

EOD personnel must be trained to safely disarm and diffuse bombs, mines, rockets, warheads, improvised explosive devices (IEDs), and other types of ordnance. To effectively train personnel the experience must be realistic. It is necessary to train in real time, using replicas or training aids that simulate the reactions of the ordnance. Expectations are that the OPS concept will do just that.

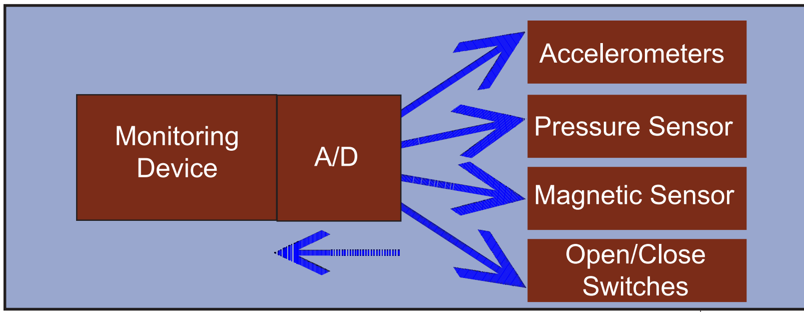
Currently, EOD personnel train by running detonating cord to an actual explosive located at a safe distance away from the trainee. The use of actual explosives requires strict adherence to approved Standard Operating Procedures (SOPs). If an error is made by the trainee during the simulated training the explosive is detonated to indicate that the student made a mistake and paid with his "life." There is also the possibility the student made a mistake and the explosives did not detonate. Extra wait time is then required to obtain necessary, yet time-consuming, approvals as prescribed in the misfire procedures. It is important to note that every time EOD personnel work with explosive material there is potential for serious injury.

Also, the conventional method of training limits the number of personnel that can be trained in a given amount of time. For each trainee, there must be one qualified trainer overseeing the training exercise. Several days are required to set up and complete the training. Therefore, it is very time-consuming to train a large number of EOD personnel.

The OPS tool gives a realistic training experience with immediate feedback, no explosives, and the ability to monitor several variables simultaneously. Because different types of ordnance are detonated in different manners, the OPS tool must be able to detect a variety of external forces that could detonate the ordnance implemented with sensor arrays.

The OPS tool consists of various plug-in sensors both inside and surrounding the ordnance, which are attached to the input port of a hand-held monitoring device. Examples of the types of sensors that can be triggered on the ordnance include accelerometers, pressure sensors, magnetic sensors, timers, and open/close switches. Other sensors desired by the EOD community may also be included.

When the EOD trainee has violated any of the ordnance thresholds, OPS will provide an alert notifying the trainee that a sensor was triggered, indicating the ordnance would have detonated. OPS will have an option to provide either a loud audible warning or a visual warning. OPS engineers would like the audible warning to sound like an explosion making the training exercise as realistic as possible.



Ordnance Penalty Simulator Concept

Because different types of ordnance respond to different external factors, the trainer will be able to plug in sensors to the hand-held monitoring unit as appropriate for each particular type of ordnance used in the training exercise.

For example, some types of ordnance are actuated by pressure, but magnetic fields have no effect on them. In that case, the OPS monitoring device would only need to be plugged into the pressure sensors. The multiple jacks on the hand-held unit give the OPS tool a great degree of versatility.

There are two ways the OPS could be utilized in training. In the first, the trainer is physically present with the trainee as the ordnance training device is disarmed. In this instance, the hand-held monitoring device is hardwired to the sensors on the ordnance and the trainer is with the trainee.

In the second option, the trainer is at a remote location with a master monitoring device. The ordnance sensors interact with a slave monitoring device located on the ordnance. The slave monitoring device then transmits to the master monitoring device via a spread spectrum short radio frequency link (i.e. ultrawideband or wireless network) allowing the trainer to monitor several trainees at once through the master monitoring device.

Option two will make training more efficient as more personnel will be trained in a given amount of time. In addition to monitoring multiple users, the training will be more precise and informative since the OPS tool can monitor multiple variables at once and offer instant feedback.

Although OPS is still in concept form, the vision is to have a color LCD display with touch-screen and front-light, a membrane keyboard, a four-direction cursor control button, and a built-in self-test.

Many of the components required can be commercial off-the-shelf products, including the lithium ion rechargeable battery, and an analog/digital (A/D) converter to convert sensor output.

For the hand-held device to read the signals from the sensors, the signal must be digital. But some of the sensors, for example magnetic sensors, send analog signals. An A/D converter is needed to translate these signals so that the hand-held monitoring device can interpret them.

Software will be developed for the OPS to select the type of ordnance used in the training exercise and the appropriate sensors for that particular ordnance, and to give the failure alerts.

Ultimately, the customer will determine the final specifications. For example, customers may look at this concept and say they need a battery that lasts longer, rechargeable, lithium type, 12 volts or other specifications. If that is the case, then a battery will be used to achieve that requirement. Engineers designing the OPS will adjust efforts to meet the customer's needs.

Funding is needed to further develop this concept and make it a reality. Expectations are that OPS has potential for use by agencies other than the Navy, such as the FBI or Secret Service.

This concept will help EOD personnel be better trained and prepared for their work. When EOD personnel encounter mines, for example, it should become second nature to them to be able to successfully disarm them.

ATOS: Ensuring Mission Readiness

by Melissa Miller
Energetics Evaluation Department

The Advanced Technology Ordnance Surveillance (ATOS) system will provide ordnance managers, and ultimately the warfighter, the capability to immediately know what is available in their stockpile, where it is located, and its condition.

ATOS combines Radio Frequency Identification (RFID) and sensor technologies to provide an efficient way to manage ordnance stockpiles, monitor and record asset life-cycle environmental history and provide alarms when a user-defined environmental threshold is exceeded for any of the sensors.

Why is environmental surveillance so important? The average design life of ordnance is 5 to 8 years, but the average in-service age of the ordnance stockpile is approximately 25 years. Ordnance ages over time inducing chemical and physical changes. Environmental stressors accelerate the aging process and increase the ordnance vulnerability to adverse stimuli. This aging affects the safety, reliability and performance of ordnance. Therefore, it is very important to know what environmental extremes an item has experienced.

The military logistics environment can be a combination of extreme temperatures, poor handling conditions and poor storage conditions. For example, during Operation Iraqi Freedom, an incident occurred where one container from a shipment of 8 Patriot missile containers was dropped. As this container had no visible damage, there was no way to determine which of the 8 Patriot missile containers had been dropped. Due to the possibility of damage to the solid grain propellants or guidance components, all 32 Patriot missiles (8 containers) were sent back to the states to be evaluated and repaired as necessary. The cost incurred totaled over $21.9 million. This is one example of the unbudgeted expenses that can result from an environmental extreme.

The environmental data collected allows commodity managers to prioritize the use of their stockpiles and allows the quality evaluation personnel a means to enhance predictive and statistical modeling, refine test sample selections, increase insight during engineering investigations and improve future missile designs.

ATOS was developed and funded by a Joint Service program known as Advanced Concept Technology Demonstration (ACTD). The intent of the ACTD program is to accelerate the traditional system acquisition process by adapting mature commercial off the shelf (COTS) devices and/or technologies to satisfy

Unless there is visible damage, there is no way to know if an asset has been exposed to environmental extremes that could affect its future performance.

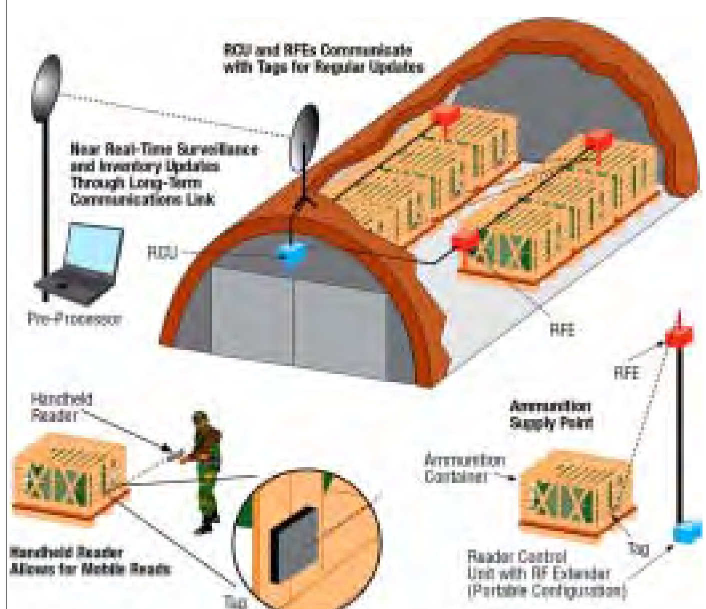
The management of ordnance stockpiles can be very labor intensive, prone to human errors (requiring duplication of efforts) and lack in visibility.

immediate or emerging warfighter needs.

ATOS is a non-proprietary open architecture system that can be used wherever ordnance is stored. ATOS does not require an infrastructure or a business process server. Its software application will be integrated into the ammunition inventory management systems of each service. Substantial benefits can be realized with a basic ATOS configuration. The basic ATOS configuration consists of a handheld reader, RFID tags with sensors, docking station, and application software. Additional benefits, such as automated inventory management and ordnance surveillance, can be realized with the addition of a reader control unit (RCU) in the storage area. For large storage areas, radio frequency extenders (RFEs) can be attached to the reader control unit to ensure a 99.9% accuracy in tagged item visibility. Lack of AC power or network connectivity does not prevent the use of the fixed reader system (RCU and RFEs) as it can be powered by an external 24-volt DC source for download of its 'inventory' onto a handheld reader. This allows for ATOS use in harsh environments such as battlefield distribution sites where permanent power and communication link are unavailable.

ATOS has three main functions: automated identification, automated inventory management, and automated sensor data collection. For automated identification, ATOS uses active data-rich tags that contain all of the data elements common and unique to all of the service AISs. This allows for the full automation of MILSTRIP and MILSTRAP transaction feeds. The data on these tags can also be

Open storage area at the Reserve Storage Activity in Miesau, Germany in March 2004. ATOS radio frequency extenders mounted on masts are seen in the background.



The concept of operations for ATOS.

Pallets with ATOS tags in a magazine at the Crane Army Ammunition Activity.

Sailors reading ATOS tags in magazine on board the USS Truman during final Military Utility Assessment Demonstration.

changed remotely an unlimited number of times without the human labor involved to do the same with barcodes. For automated inventory management, ATOS allows a commodity manager to search their stockpiles worldwide by quantity and location. Finally, the ATOS tags contain four sensor ports that can be configured for any customer's application. The sensor readings are taken every hour and stored in both histogram and serial data formats. The histogram data is a 2 KB file that is collected autonomously whenever a handheld transaction is performed - i.e. issue, receive, transfer, partial issues, etc. This data, when graphically represented, can provide a means to quickly prioritize the use of ordnance. Serial data is also collected and stored for up to 14 years, but not transmitted autonomously due to its large size. This data can be collected remotely or with a handheld reader.

Although ATOS was designed primarily for ordnance, due to its flexible design, any commodity that degrades over time and with extreme temperature can realize ATOS benefits. ATOS recently completed a pilot test on personnel protective equipment (October 2004) and will begin a life raft pilot test in January 2005.

ATOS successfully completed field demonstrations at end of 4th quarter FY04. Demonstrations or Military Utility Assessments (MUAs) were conducted at Crane Army Ammunition Activity (AAA), Miesau Army Ammunition Depot in Germany, and aboard two Navy ships. An air shipment from the Crane AAA to the Norfolk Naval piers was also performed.

The ATOS capability will significantly enhance CONUS and theater ordnance visibility, accountability, safety, and life cycle management from sub-component to complete rounds. It allows for improved ordnance stockpile management and usage prioritization and provides the data needed by Quality Evaluation Teams to improve predictive and statistical modeling, refine test sample selection for Service Life Assessment Programs, insight into engineering investigations, and improvements in future ordnance designs.

If you would like more information on ATOS or would like to see an operational magazine configuration, please contact Melissa Miller, Predictive Technologies Branch Manager on 301-744-4879 or via email at millermo@ih.navy.mil.

IHDIV/NSWC Evaluates Upgraded CKU-5C/A Rocket Catapult with Ejection Seat Sled Tests

by Craig Wheeler
CAD/PAD Department

The CKU-5C/A rocket catapult propels the ACES II ejection seat through-the-canopy in this A-10 system test at Holloman AFB, New Mexico.

You may have seen extremely fast-moving land vehicles, perhaps at a drag strip, where top speeds can exceed 300 mph, but you likely have not seen an earthbound vehicle traveling supersonic at over 800 mph until you have witnessed a high-speed sled test. That is the velocity the multi-staged rocket-propelled 4-ton F-15 fuselage and pusher sled assembly reaches, five seconds after launch, when it performs a 600-knots-equivalent-air speed (KEAS) ejection seat test.

Secured by sets of captive slippers to a pair of continuous steel rails anchored to bedrock at the 12,000-ft long Hurricane Mesa Test Facility, the sled vehicle provides dynamic test conditions that represent those conditions a pilot may face when ejecting from a stricken aircraft. Days and weeks of meticulous test preparations culminate into only a

CKU-5C/A rocket catapult section view and shown installed on ACES II ejection seat.

few seconds of elapsed time for the ejection test. The CAD/PAD Department at Indian Head Division, Naval Surface Warfare Center (IHDIV/NSWC) recently saw the culmination of its preparations with the completion of a series of five ACES II ejection seat tests of the redesigned CKU-5C/A Rocket Catapult in support of the Air Force in its Joint CAD/PAD Program. The upgraded rocket catapult was developed and qualified by IHDIV/NSWC to replace the current CKU-5B/A version of the rocket catapult. The CKU-5C/A uses modern hydroxyl-terminated polybutadiene (HTPB) composite propellants that offer reliable performance, extended service life, and continued producibility. Working with Air Force and industry team members, IHDIV/NSWC planned and executed the sled test program, performed at two separate test track facilities, to evaluate static and dynamic ejection seat performance in F-15, F-16, and A-10 aircraft configurations, using state-of-the-art anthropometric test dummies representing an expanded range of crewmembers: a 245-lb large male and a 103-lb small female.

The CKU-5C/A Rocket Catapult is the primary propulsion device for the ACES II

Milton Reese and Tom Briscoe of IHDIV/NSWC watch as test crew members hoist an ACES II ejection seat fitted with the large 245-lb male test manikin into the F-15 sled.

The ejection seat is positioned in the guide rails with the CKU-5C/A in position for final installation.

ejection seat equipped A-10, F-15, F-16, F-117, F-22, B-1, and B-2 attack, fighter, and bomber Air Force aircraft. The rocket catapult is a two-stage combination device that first launches the seat and crewmember from the aircraft cockpit via its telescoping tube catapult, powered by a CCU-22B/A impulse cartridge, and then propels the seat and aircrew member with its integral composite propellant rocket motor to a safe trajectory height for parachute recovery, whether ejecting at altitude or at ground level.

It is one of several cartridge actuated device/propellant actuated device (CAD/PAD) energetic devices that provide initiation, deployment, propulsive, and other functions on the ejection seat and escape system.

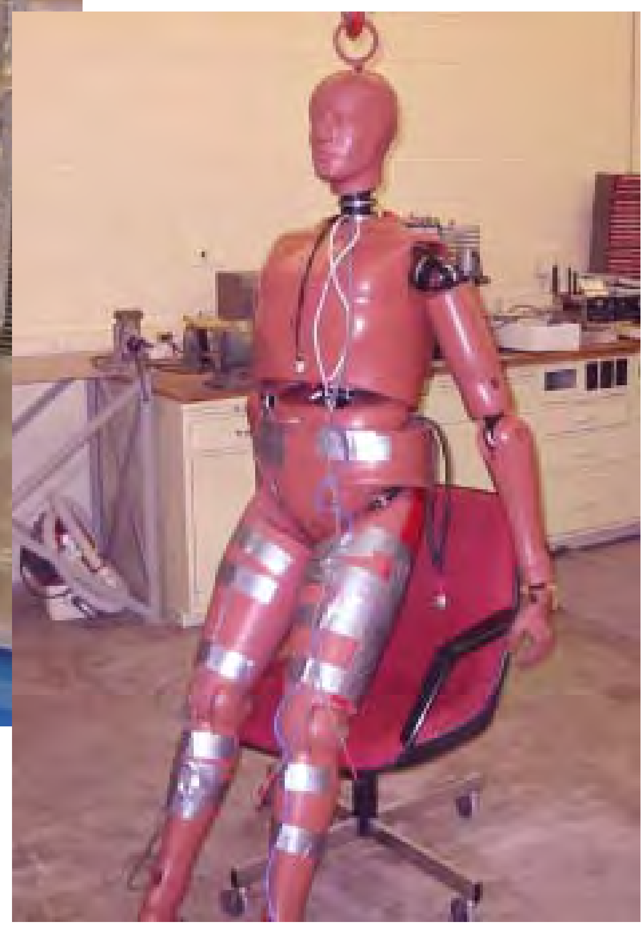
The five CKU-5C/A rocket catapult ACES II ejection seat tests used three aircraft seat configurations and two test track facilities. Goodrich AIP conducted four of those tests at their Hurricane Mesa Test Facility, located in southern Utah, using an F-15 fuselage sled. The Holloman Air Force Base (AFB) High Speed Test Track in New Mexico hosted the fifth test, using an A-10 aircraft sled and corresponding ACES II configuration seat in through-the-canopy backup mode.

The five tests provided a cross-section of ACES II escape system critical conditions, including minimum (zero) and maximum (600 KEAS) velocity ejection conditions, as well as through-the-canopy backup mode. The test conditions represented those most demanding of the rocket catapult across its range of required escape system performance.

Although such capability wasn't necessary for the static

An ACES II ejection seat with a small 103-lb female test manikin and fitted flight gear is measured for center-of-gravity and moment of inertia properties in preparation for testing.

A-10 ACES II test performed there for the CKU-5C/A program, the Holloman High Speed Test Track at Holloman AFB, New Mexico, offers the world's longest test track stretching 10 miles adjacent to the White Sands Missile Test Range, and holds the world land speed record of 8,453 mph for a railed vehicle set in 2003. IHDIV/NSWC worked closely with the Holloman AFB test personnel to accomplish the through-the-canopy



Anthropometric test manikins, such as this 245-lb male JPATS Case 6 with internal 40 channel data acquisition systems, record data from sensors located in the head, neck, chest, and lumbar as well as from seat-mounted sensors.

Jim Rooney of Brooks City Base performs an inspection of pilot flight equipment during final preparations for test.

A-10 testing that further confirmed the CKU-5C/A compatibility with the ACES II escape system.

The test configurations used expanded-range test manikins representing a large male weighing 245 lb, and a small female weighing 103 lb. The test manikins are carefully surveyed for center-of-gravity and inertial properties before each test. They are equipped with sensors and an internal 40-channel data acquisition system that record seat and manikin acceleration, loads, and other dynamic data used to assess escape system performance and predict crewmember injury potential. A series of high-speed film and video cameras capture trajectory and documentary data that assist engineers in analyzing the test outcome.

For each ejection seat sled test, IHDIV/NSWC personnel obtained trajectory and performance data that provided information on the CKU-5C/A functional performance. In addition, post-test disassembly and examination of the fired catapult hardware provided marginality of success assessment of the design.

IHDIV/NSWC also completed a thorough component qualification program for the CKU-5C/A Rocket Catapult that included 47 complete rocket catapults and 28 CCU-22B/A cartridge test articles.

Hurricane Mesa Test Facility is all but hidden atop a remote mesa in Southern Utah where the 2.25-mile dual rail sled track perches 1,500 ft above the surrounding land. Owned and operated by Goodrich AIP, who also builds the ACES II ejection seat, the facility has provided static and dynamic test environments for escape test programs since the 1950s.

The instrumented ejection seat accelerated by the CKU-5C/A rocket catapult carries the test manikin up and away from the F-15 sled to an automated parachute recovery over 150 ft above the ground.

Testing included environmental conditioning and ballistic static firing tests at -65, 77, and 165 °F using combined seat/crewmember ejected masses that represented nominal and an extended range of male and female aviators. The ACES II ejection seat system sled tests supplemented this qualification program with an evaluation of the rocket catapult performance compatibility with the ejection seat system.

Ejecting from an aircraft is a last resort that few pilots ever have to experience, particularly at the extremes of the ejection envelope encompassed in a sled test program. However, thanks to CAD/PAD components like the CKU-5C/A rocket catapult, that capability is available if needed, ready to save a life.

Joint NAVSEA/Air Force Team Evaluates *Quickstrike* Operational Reliability

by Michael Crawford
Weapons Department
Yorktown Detachment

As part of the Naval Ordnance Safety and Security Activity (NOSSA) Quality Evaluation (QE) Program, IHDIV Det Yorktown teamed with the Air Force, Mine Warfare Command (COMINE-WARCOM), and NAVSEA PMS-495 to conduct an In-Water Reliability Evaluation (IRE) of the Mk 63 and Mk 65 (*Quickstrike*) mines. This effort evaluated the operational reliability of these in-service mines.

The IRE test program is one part of an ongoing quality assessment program to increase Fleet readiness, ensuring the continued successful operation of weapons and ordnance in the Navy's inventory. The program was coordinated, directed and supported over an 11-month period by personnel from IHDIV/NSWC and IHDIV Det Yorktown.

Quickstrike is a series of bottom-laid mines that provide the Navy a mining capability against all targets in shallow water regions. *Quickstrike* is available in three sizes: the 500-lb Mk 62 and 1000-lb Mk 63 mines, which are kitted Mk 80 series general purpose bombs, and a Navy-

Installation of mine cables at MOMAU ELEVEN.

Installation of access cover at MOMAU ELEVEN.

mine-unique 2000-lb Mk 65 version. The Mk 65 is the Navy's largest conventional munition. The latest *Quickstrike* mines are programmable and modular, allowing them to be updated to keep abreast of emerging threat targets. Ongoing developments include new target detecting devices and target processing algorithms.

COMINEWARCOM's Mine Plans and Requirements Department (N5), is responsible for the development of minefield plans, doctrine, and tactics in support of world-wide fleet operational plans. N5 also is responsible for development of the non-nuclear ordnance requirements (NNOR) for sea mines, which includes direct liaison with all Fleet Commanders in Chief, Numbered Fleets, and other technical agencies to ensure the sea mine requirements accurately reflect the Navy readiness needs and support operational Fleet plans. Reliability information from this year's IRE is provided to these minefield planners to ensure fields are not over-saturated due to a perceived low reliability, or under-mined due to too high an anticipated reliability.

IREs are one of the few QE programs that exercise a weapon system in a real world environment, evaluating the weapon system, the maintenance process and launch platform, and utilizing Fleet personnel. Historically, IREs have uncovered mine system problems such as case integrity failure, out of alignment explosive trains, drag chute failure, and failure to respond to the target. These areas and others will be evaluated during post analysis, and data from this evaluation will be used to generate recommendations to the program office for maintenance or replacement of low reliability components.

The FY04 IRE was very successful, providing an excellent snapshot of the Fleet's ability to assemble mines, joint service teamwork, and the current reliability level of the Mk 63 and Mk 65 mines. The Mk 65 continues to perform above design requirements. The Mk 63 is performing at an acceptable level with anticipated failure trends emerging. COMINEWARCOM minefield planners developed a minefield-planning folder used by the test director at IHDIV Det Yorktown, Mobile Mine Assembly Unit (MOMAU) Eleven, and the Air Force, identifying mine types,

Quickstrike Mk 63 mines being loaded on B-52H stations.

Mk 63 entering the water.

Rear deck of recovery vessel.

Jerry Ellis and Bill Treadwell, IHDIV Det Yorktown, review mine GPS data.

USAF weapons loading crew.

operational settings, and the minefield layout. The first phase of operations began 21 June with mine build up by MOMAU Eleven in Charleston, SC.

Following the planning folder, MOMAU Eleven assembled Condition Code A components into 20 Mk 63 and 20 Mk 65 inert-loaded *Quickstrike* mines. The mines were assembled following NAVSEA mine assembly service publications, with QE hold points to allow installation of multi-event recorders by IHDIV Det Yorktown personnel. QE multi-event recorders captured critical events such as mine activation and weapon response to target.

For long range and large minefield delivery during wartime, the Air Force would be the desired launch platform for *Quickstrike*. Due to limited availability of Navy aircraft and the number of weapons tested, the Air Force was chosen as the FY04 IRE delivery platform. Upon completion of mine assembly, they were shipped to Barksdale Air Force Base where they were loaded by the Air Force Second Operations Support Squadron onto four B-52H Bombers operated by the 20th Bomb Squadron. The squadron planned anticipated splash points that corresponded to requirements of the minefield-planning folder. Aircraft launch, flight altitude, and weapon delivery followed wartime criteria. After a flight of approximately 90 minutes, each of the 40 mines were successfully delivered into the waters off Florida's gulf coast at the NSWC Panama City Test Range on 21-22 July.

With pingers attached to the mine case, Explosive Ordnance Disposal (EOD) Mobile Unit Six divers from NSWC Panama City located and attached a floating marker to each mine. IHDIV Det Yorktown personnel then used GPS equipment to document each mine's exact location. The USS *Carney*, a Navy destroyer, provided a real-world ship signature to test the reliability and performance of each of the mines in the minefield on 29 and 30 July. After several passes of the USS *Carney* over or near each mine to trigger the mines, EOD Mobile Unit Six divers recovered the mines. Finally, the mines were transported to NSWC Panama City for post-test analysis. Initial analysis began on the recovery vessel to identify physical damage and verify arming device operation. Detailed post-test analysis is currently underway at IHDIV Det Yorktown.

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